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OPERATION MODELING FEATURES OF TURBINE TYPE FLOW RATE TRANSDUCERS

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The instruments based on turbine flow rate transducers take a certain part of the instruments market for measuring liquids flow rate and amount for many years. Such instruments are widely used in housing and communal services, petrochemical, fuel, energy, food and other industries. This is due to the advantages of the method such as high accuracy, reliability, the ability to directly obtain a frequency-modulated signal, the design simplicity and adaptability, small pressure losses. The presence of a movable element in the flow transducer design is the main disadvantage of these instruments today.

But the sensitive element (SE) shape as well as the flow part configuration provides the metrological characteristics of turbine flow meters and meters.

The aim of the research is to define the spatial shape of the sensitive element SE that provides the best measurement accuracy in the flow rate variation range.

Modern production technologies and materials on the one hand and the computational fluid dynamics rapid development on the other hand make it possible to create any spatial form of the SE.

Sensitive elements of two different spatial forms were selected to achieve the goal:

- a turbine which is a cylindrical hub with helical blades;
- a turbine with a coaxial ring mounted on the SE middle radius, its thickness is equal to the blade profile thickness.

The studied SE varieties are considered under conditions of identical general structural parameters such as characteristic radii, number of blades and other overall dimensions. This makes it possible to install them in the same transducers.

The measurement process for this type flow transducer is described by the equation of SE rotational motion under the flow action. The components of this equation are functions of the measuring medium flow properties, the configuration parameters of the instrument body and the SE. In this case such properties of the measured medium flow as temperature, pressure, density, viscosity, speed are taken into account. The configuration parameters of the instrument body are the radii and lengths of the flow tube characteristic sections. The SE is characterized by the number of blades, the angle of their inclination, the blades height and thickness, the turbine axial length.

The most important elements of such transducer's mathematical model are the driving torque from the measuring medium incoming flow and the SE inertia moment.

The turbine type transducer feature is the creation by structural elements of the annular channel for the measuring medium flow. It's created by the SE hub radius and the inner radius of the body measuring part.

Therefore, it is necessary to take into account the measuring flow movement in the annular channel when creating the transducer mathematical model. This effect is displayed in the mathematical model of the torque. The annular channel characteristic size is the radius corresponding to the maximum flow velocity [3]. This parameter combines the flow transducer design parameters with the hydrodynamic properties of the measured flow and is the function of the radii forming the annular channel.

At the same time the torque from the measured medium flow is formed at the height of the SE blade which is determined by the difference between the turbine outer radius and the hub radius.

In the general case the expression describing the indicated moment has the form

$$M=f(a_1, a_2, \dots, a_n, b_1, b_2, \dots, b_m), \tag{1}$$

where, $a_1, a_2, \dots, a_n$ – are the characteristics of the measured flow; $b_1, b_2, \dots, b_m$ – geometric features of the transducer flow tube.

The studied SE moments of inertia are determined based on the inertia of their individual components (hub, blade), their number and relative position in spatial form. In this case the measured medium masses attached to the SE are taken into account [4]. In addition to the SE geometric characteristics the required components of the moment of inertia are the material's density, as well as the medium flow density

$$J=f(c_1, c_2, \dots, c_k, d_1, d_2, \dots, d_q), \tag{2}$$

where, $c_1, c_2, \dots, c_k$ – geometric parameters of the SE spatial form; $d_1, d_2, \dots, d_q$ – the SE material density, the measuring medium density, the attached masses coefficients of the SE parts.

Expressions (1) and (2) obtained for the studied SE varieties became the basis of the corresponding transducers mathematical models.

The research results of the measurement error of the flow transducers with different SE are presented in the report. These results are obtained by mathematical modeling.

Key words: turbine type flow rate transducer, sensitive element, spatial form, measurement error.

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